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IMPACT OF MAIZE RESEARCH AND EXTENSION IN BANGLADESH

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ABSTRACT

The study was undertaken during 2001-02 to evaluate the past investment on research and extension of maize in Bangladesh. For the purpose, Economic Surplus Model with ex-post analysis was used to estimate the returns to investment on composite varieties and hybrids of maize that have replaced the local varieties. The growth rate of area, production and yield of maize were increased dramatically after the release of maize varieties. The internal rate of return (IRR) to investment was calculated at 23%. During 2000-01, about 65.70% more maize production was made available because of the farmers' adoption of composite varieties and hybrids of maize. The yield of composite varieties of maize ranged from 40 to 65% and hybrids ranged from 73 to 79% higher over the local varieties. Under various assumptions about the research and extension expenditures, the IRR ranged from 17 to 28% and benefit cost ratio from 9 to 19. The accumulated foreign exchange saving since 1992-93 was Tk 291.59 billion. The study indicates that the funding of maize research and extension is a good investment. Therefore, both government and donor agencies should come forward to invest in maize research and strengthen extension activities in the country.

I. INTRODUCTION

Maize is the third major cereal after rice and wheat in Bangladesh. Its yield is much higher than rice and wheat. Further, it is grown both in winter and summer seasons in Bangladesh. Therefore, it has the opportunities to cover more areas round the year and it can contribute greatly in food supply for the growing people in the country. During last few years, farmers have adopted greatly the cultivation of composite varieties and hybrids of maize in their farming systems due to many reasons. It is now widely used in the poultry farms and animal feeding, and roasted and fried maize are consumed by the people. But major part of this demand is fulfilled by importing maize from other countries. This results the demand for increasing maize production in the country. However, to meet the increasing demand for

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maize, the farming sector, profitability of maize and its marketing are the key determinant factors.

The Maize Research Program of Bangladesh Agricultural Research Institute has developed five composite varieties and two hybrids of maize along with other improved technologies. Five composite varieties of maize namely Bornali, Khoi Bhutta, Mohar, BARI Bhutta-5, BARI Bhutta-6 and two hybrids namely BARI Hybrid-1 and BARI Hybrid-2 were developed during 1986 to 2001. Now, for the dissemination and promotion of these varieties, DAE (Department of Agricultural Extension) and different NGOs (non-government organizations) are closely working with BARI (Bangladesh Agricultural Research Institute). For research and extension and promotion of maize in the country, different costs are involved which need to be economically evaluated. Further research and extension activities of maize can be undertaken on the basis of this evaluation. Therefore, the present study was undertaken to see the impact of research and extension investment to provide information for the policy makers, donors, researchers and extension people for the improvement of the crop.

Objectives of the Study

i. To estimate the growth rate of area, production and yield of maize;
ii. To estimate the adoption of composite varieties and hybrids of maize and yield advantages over local varieties and
iii. To estimate the rate of returns to maize research and extension investment.

II. DATA AND RESEARCH METHODOLOGY

Data

In the present study, data from different sources were used like published, unpublished, formal interview of the maize growers and informal scientists interview. Area, production and yield of composite varieties and hybrids of maize, maize harvest price and consumer price index (CPI) were collected from various issues of Statistical Yearbooks published by the Bangladesh Bureau of Statistics. Import prices of maize were collected from the Export Promotion Bureau, Motijheel, Dhaka. The demand and supply elasticities were chosen after consultation of studies in this field. Since BARI is the principal institute for maize research, the research cost included mainly from BARI and the donor agencies like UNDP (United Nations Development Program) and ASSP (Agriculture Support Service Project). The extension and promotion activities were done by GKF (Grameen Krishi Foundation) and DAE (Department of Agricultural Extension) and the related costs were collected from these organizations. BARC (Bangladesh Agricultural Research Council) mainly provided the administrative costs. The farm level yield data of different composite varieties and hybrids of maize were collected from the maize program of BARI.

Analytical Procedure

The Economic Surplus Model with Ex-Post analysis was considered for the present study to estimate the rate of returns of the composite varieties and hybrids of maize that have been

replacing the traditional varieties of maize. The analysis was attempted with the open-economy. The open-economy commodity market is defined as a commodity that is totally produced and consumed domestically as well as the commodity is imported or exported.

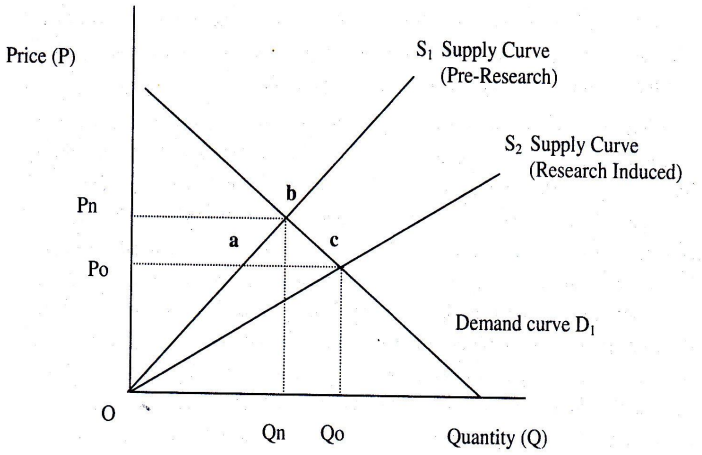
Period of Study

The study was conducted during 2001-02. The study period covered from 1980/81 to 2000/01. The benefits were considered from past maize varietal development beginning 1986, the year when the first composite variety Bornali was adopted and sown by the farmers.

Economic Surplus Model

The economic surplus concept has been adapted to estimate the benefits from the adoption of improved varieties. The components of economic surplus are consumer surplus and producer surplus. Given the initial condition (i.e., pre-research supply curve S_1 and demand curve D_1), consumer surplus is depicted as Area PoPnb in Figure-1. This is the surplus or benefit to consumers because of a functioning market. Consumer surplus is that area beneath the demand curve less the cost of consumption. The cost of consumption is the area below the price line P_n. Producer surplus is defined by Area P_nb0 in Figure-1. Area P_nbO is the surplus left to the farmers after they have paid for the total costs of production, area ObQ_n (Alston *et al.*, 1995).

Figure 1. Closed-Economy Economic Surplus Model



Change in Consumer Surplus	=	Area abc + Area PnbaPo
Change in Producer Surplus	=	Area Oac - Area PnbaPo
Change in Total Economic Surplus	=	Area abc + Area Oac

The adoption of an intervention by farmers such as an improved variety usually means one of two things: i. a farmer can supply more of the commodity using the same level of resources (i.e, same land area and other inputs), or ii. a farmer can supply the same level of commodity output but do it with less resources. In either case, this is depicted by a shift to the right of the supply curve as shown in Figure-1 (the shift is from S_1 to S_2). This shift is the supply curve from the adoption of an intervention changes the initial equilibrium price and quantity of the commodity. This new price quantity equilibrium increases economic surplus. The change in economic surplus (economic benefits) is measured by comparing the difference in economic surplus between the pre-adoption period and the post-adoption period.

Given a shift in the supply curve S_1 to S_2, the change in consumer surplus is depicted in Figure-1 as Area abc + Area P_nbaP_o. The shift in the supply curve (due to the adoption of an intervention) has decreased the price consumers now have to pay for the commodity.

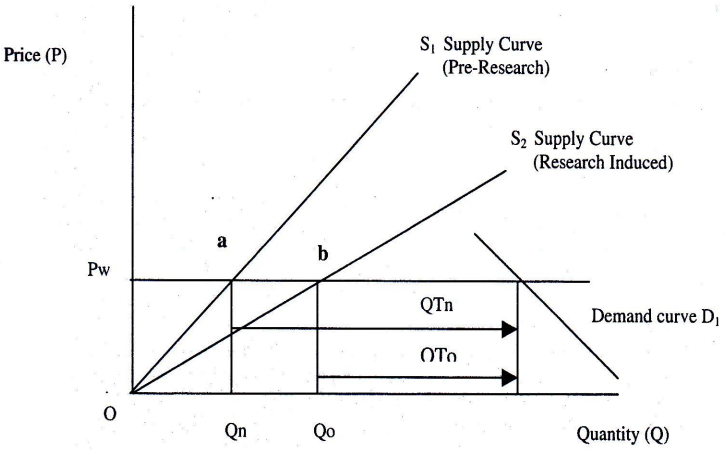
Given a shift in the supply curve S_1 to S_2, the change in producer surplus is depicted in Figure-1 as Area Oac–Area P_nbaP_o. Area Oac in Figure-1 represents the decrease in the cost of producing the same unit of the commodity that farmers now enjoy because they are using the intervention. This represents the benefits to the farmers from adopting the

intervention and can be measured and quantified in monetary terms. The adoption of the intervention, however, has increased the quantity produced thereby decreasing the price of the commodity (P_n to P_o in Fig-1) and is a loss to farmers' income. Farmers do make back some of this loss because now they sell more quantity (Q_n to Q_o in Fig-1) of the commodity.

The total social benefits to society from the adoption of an intervention is the summation of the change in consumer surplus plus the change in producer surplus (Area abc + Area Oac) minus the input cost change from adopting the new interventions.

The change in economic surplus for small open-economy for maize is depicted in Figure-2. The world price Pw and quantity demanded by the consumers Q_1 defines the initial equilibrium. At price Pw, producers supply Qn amount of maize when faced by the pre-research supply curve S_1. Maize imports are equal to QTn. When faced by the research induced supply curve S_2 (the supply curve that exists because farmers have adopted improved varieties), maize producers increase production to quantity Q_0, an increase of QnQ_0. Maize imports are decreased by the same amount as the increase in production QnQ_0 and is now at QT_0. Because the price Pw does not change (small country assumption), there is no change in consumer surplus-consumers are neither better off nor worse off. The entire change in economic surplus from the adoption of new maize varieties is thus a change in producer surplus only and is identified by area 0ab in Figure-2 (corresponds to Area 0ac in Fig-1). The amount of foreign exchange saved by the adoption of improved maize varieties in equal to Pw x (QnQ_0).

Figure 2. Small Open-Economy (importer) Economic Surplus Model



Pre-Research : Quantity QTn imported
Research Induced : Quantity QTo imported

Akino and Hayami Method: Empirical Approach

The Akino and Hayami (1975) approximation formulas for calculating changes to producer and consumer economic surplus are described below and these are used in this study. The Akino and Hayami (1975) approximation formulas for calculating the change in economic surplus for a open-economy analysis (Fig-1) is as follows :

Area A (abc) = $0.5\ PoQo\ ((k\ (1+\gamma))^2/(\gamma+\eta))$ (1)

Area B (Oac) = $kPoQo$ (2)

Area C (PnbaPo)=$(PoQok(1+\gamma))/(\gamma+\eta))\ x\ (1-((0.5k(1+\gamma)\ \eta)/(\gamma+\eta))-0.5k\ (1+\gamma)$ (3)

Where,

Po = Commodity price (existing market price)

Qo = Quantity of the commodity (existing production)

Pn = Quantity price that would exist in absence of research

Qo = Quantity of the commodity produced that would exist in absence of research

k = Horizontal supply shifter

γ = Price elasticity of commodity supply

η = Absolute price elasticity of the demand for the commodity.

The Supply Shifter k

The supply shifter k i.e., the overall yield advantage of improved varieties over the old varieties weighted by the area sown to the new varieties and is called the supply shifter. In the case of the Akino and Hayami (1975) approximation formulas, k is the horizontal shift from the equilibrium price Pn given S_1 to the equilibrium price Po given S_2 which corresponds to a distance equal to QnQo in Figure-1 (Gardiner, *et al.*,1986). The supply shifter k is calculated as follows:

$$k_t = \sum_{i=1}^{n} [1 - \frac{Y_t}{Y_{it}})] \times A_{it} \qquad (4)$$

Where,
Y_{it} = Yield of the improved variety in year t
Y_t = The yield of a base (or average yield of old varieties) that has been grown in the past and that would still be grown if no new varieties had been developed
A_{it} = The proportion of the total area sown to variety in year t
n = The number of improved varieties

Internal Rate of Returns

The internal rate of return (IRR) is calculated relating the total social benefit (TSB) minus an input cost change, if any, in each year to the research expenditure (C) in each year and is the discount rate that results in a zero net present value of the benefits. The IRR is calculated as -

$$O = \left[\sum_{t=1}^{n} (TSB_t - C_t)(1 + IRR)^{-t} \right] \qquad (5)$$

The IRR can be defined as the rate of interest that makes the accumulated present value of the flow of costs equal to the discounted present value of the flow of returns, at a given point in time (Peterson, 1971).

Two types of data are mainly needed for the analysis: i. market related data, and ii. research related data. Market related data included quantity and price of maize and its supply and demand elasticities. Research related data included varietal adoption of maize, yield advantage, input cost change, and research and extension expenditures.

Research and Extension Expenditure

For the research work of maize and its extension, the contribution of BARC (Bangladesh Agricultural Research Council), DAE (Department of Agricultural Extension) and GKF (Grameen Krishi Foundation), ASSP (Agriculture Support Service Program) and UNDP (United Nations Development Program) are greatly associated with the activities of BARI (Bangladesh Agricultural Research Institute). Therefore, the total expenditures included BARI maize project expenditures, BARI-Main for salaries, DAE expenditure, BARC share of

administrative costs, GKF expenditure, UNDP expenditure and ASSP expenditures on maize. For the analysis, the current total expenditures were converted to 2000-01 constant prices using the middle income group CPI Index (Appendix-1).

Prices of Maize

The harvest prices and import prices of maize in different years were converted to 200001 constant prices using the CPI of middle income group.

Input Cost Change

There were few studies on costs and returns of different maize varieties conducted by Agricultural Economics Division, BARI, Gazipur. It was found that the average cost of local maize was Tk 16,404/ha whereas it was Tk 21,911/ha for Hybrids of maize (Hossain, *et al.* 2002). Therefore, the input cost change was found Tk 5,507/ha.

Elasticities

A supply elasticity of 0.20 was used for the present analysis. A perfectly elastic demand elasticity was used in the analysis because of the use of the small open-economy model.

III. RESULTS AND DISCUSSION

Growth of Area, Production and Yield of Maize

Three periods were considered for the growth rate calculation of maize. First, from 1980/81 to 1986/87, i.e., before the release of the composite varieties and hybrids of maize; Second, from 1987/88 to 2000/01, i.e., from the beginning of the released varieties up to the study period considered and Third, from 1980/81 to 2000/01 i.e., the whole study period.

During first seven years from 1980/81 to 1986/87, the annual rates of growth in area, production and yield of maize were 11.29, 17.79 and 6.50 percent respectively (Table-1). After the release of composite varieties and hybrids of maize, i.e., after 1986-87, the average area, production and yield of maize grew dramatically and their rates of growth were 18.28, 35.18 and 16.91 percent respectively. This might be due to the result of more adoption of composite varieties and hybrids of maize by the farmers.

Table-1. Growth rate of area, production and yield of maize

Year	Area (ha)	Production (ton)	Yield (t/ha)
1980-81	2024	1355	0.67
1981-82	2024	1322	0.65
1982-83	1619	1173	0.72
1983-84	4049	3000	0.74
1984-85	3644	3270	0.90
1985-86	3239	3000	0.93
1986-87	3239	2934	0.91
1987-88	3239	2855	0.88
1988-89	3370	3229	0.96
1989-90	3346	3350	1.00
1990-91	3109	3040	0.98
1991-92	3600	3000	0.83
1992-93	5060	7000	1.38
1993-94	6400	15000	2.34
1994-95	9940	29075	2.93
1995-96	10125	32000	3.16
1996-97	12672	40690	3.21
1997-98	14938	65279	4.37
1998-99	18494	84880	4.59
1999-00	22538	120691	5.36
2000-01	25978	149244	5.75
1980/81-1986/87:			
Mean	2834	2293	0.79
CV (%)	33	42	15
Growth Rate (%)	11.29	17.79	6.50
1987/88-2000/01:			
Mean	10200	39952	2.70
CV (%)	76	120	66
Growth Rate (%)	18.28	35.18	16.91
1980/81-2000/01:			
Mean	7745	27399	2.06
CV (%)	93	156	83
Growth Rate (%)	12.52	24.16	11.63

Source: Statistical Yearbook of Bangladesh, BBS, 1985-98, Dhaka; DAE, 2001
Growth rates were estimated by fitting OLS Semi-log function.

Varietal Adoption of Maize Varieties and Supply Shifter k

Bornali was the first popular composite variety released in 1986 followed by other composite varieties and hybrids. Several varietal experiments were undertaken since 1980 in various regions of the country but variety adoption rates were not recorded systematically except very few survey works were done scatteredly. So, the existing variety information as well as seed production information along with the considerable field experiences of the scientists were used to sketch out the percentage area sown by variety for the adoption of maize which is presented in Table-2.

Table-2.Adoption of composite varieties and hybrids of maize

Variety	Year Released	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
High Yielding Varieties (HYVs) of Maize:																
Bornali	1986	2%	3%	4%	6%	7%	9%	10%	12%	13%	14%	15%	20%	21%	22%	23%
Khoi Bhutta	1986		2%	2%	3%	3%	4%	5%	5%	6%	7%	8%	9%	9%	10%	10%
Mohar	1990					3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	12%
BARI Bhutta-5	1997												2%	3%	3%	3%
BARI Bhutta-6	1998													2%	3%	3%
BARI Hybrid-1	2000															0%
BARI Hybrid-2	2001															0%
Other Hybrids	1993							18%	20%	25%	30%	32%	35%	40%	45%	47%
% Area Sown to Local Varieties of Maize		98	95	94	91	87	83	62	57	49	41	36	24	14	5	2
% Area Sown to HYVs of Maize		2	5	6	9	13	17	38	43	51	59	64	76	86	95	98
Maize Hectares by Category:																
Total Hectares LVs		3174	3077	3168	3045	2705	2988	3137	3648	4871	4151	4562	3585	2589	1127	0
Total Hectares HYVs of Maize		65	162	202	301	404	612	1923	2752	5069	5974	8110	11353	15905	21411	25978
Total Maize Area (ha)		3239	3239	3370	3346	3109	3600	5060	6400	9940	10125	12672	14938	18494	22538	25978

Table-3. Varietywise percent area of maize and supply shifter k

Year	% Area Bornali Replacing LVs	% Area Khoi Bhutta Replacing LVs	% Area Mohar Replacing LVs	% Area BARI Bhutta-5 Replacing LVs	% Area BARI Bhutta-6 Replacing LVs	% Area Other Hybrids Replacing LVs	% Area Sown to LVs	Total Maize Area (ha)	Area Bornali Replacing LVs	Area Khoi Bhutta Replacing LVs	Area Mohar Replacing LVs	Area BARI Bhutta-5 Replacing LVs	Area BARI Bhutta-6 Replacing LVs	Area Other Hybrids Replacing LVs	Supply Shifter k
1986-87	2						98	3239	65						0.013
1987-88	3	2					95	3239	97	65					0.038
1988-89	4	2					94	3370	135	67					0.033
1989-90	6	3					91	3346	201	100					0.050
1990-91	7	3	3				87	3109	218	93	93				0.072
1991-92	9	4	4				83	3600	324	144	144				0.094
1992-93	10	5	5			18	62	5060	506	253	253			911	0.251
1993-94	12	5	6			20	57	6400	768	320	384			1280	0.285
1994-95	13	6	7			25	49	9940	1292	596	696			2485	0.340
1995-96	14	7	8			30	41	10125	1418	709	810			3038	0.395
1996-97	15	8	9			32	36	12672	1901	1014	1140			4055	0.427
1997-98	20	9	10	2		35	24	14938	2988	1344	1494	299		5228	0.504
1998-99	21	9	11	3	2	40	14	18494	3884	1664	2034	555		7398	0.574
1999-00	22	10	12	3	3	45	5	22538	4958	2254	2705	676	676	10142	0.635
2000-01	23	10	12	3	3	47	2	25978	5975	2598	3117	779	779	12210	0.657

Note: LVs = Local Varieties

Example k (2000-01)=(1-LV yield/Bornali yield)X % Area Bornali + (1-LV yield/Khoi Bhutta yield)X % Area Khoi Bhutta + (1-LV yield/Mohar yield)X % Area Mohar + (1-LV yield/BARI Bhutta-5 yield)X % Area BARI Bhutta-5 + (1-LV yield/BARI Bhutta-6 yield)X % Area BARI Bhutta-6 + (1-LV yield/Other Hybrids yield)* % Area Other Hybrids = 0.657

The supply shifter k was calculated using the equation (4) and found that during 2000-01, 65.70 percent more maize production was made available because of farmers' adoption of composite varieties as well as hybrids of maize (Table-3).

Yield Advantage of Composite Varieties and Hybrids of Maize

Composite varieties and hybrids of maize have replaced the local varieties starting in 1986. The potential yields of Bornali, Khoi Bhutta, Mohar, BARI Bhutta-5, BARI Bhutta-6, BARI Hybrid-1, BARI Hybrid-2 and other Hybrids average were recorded as 6.00, 3.75, 5.00, 6.00, 6.50, 8.25, 8.50 and 10.50 ton/ha respectively and the local variety 2.25 ton/ha. Thus the potential relative yields of composite varieties and hybrids of maize were 40 to 79 percent higher over the local varieties (Table-4).

Table-4. On-farm yield of maize varieties and yield advantages

Variety	Yield (t/ha)	Yield Advantage
Bornali	6.00	0.63
Khoi Bhutta	3.75	0.40
Mohar	5.00	0.55
BARI Bhutta-5	6.00	0.63
BARI Bhutta-6	6.50	0.65
BARI HN•brid-1	8.25	0.73
BARI Hvbrid-2	8.50	0.74
Other Hybrids	10.50	0.79
Local Variety	2.25	

Source: Maize Program, BARI (on-farm data)

Rate of Returns from Maize Research and Extension

Equations (1) through (3) were used to estimate the total social benefits to maize research and extension expenditures. The equations were embedded into a computer spreadsheet for ease of computation. First, the yearly total social benefits were estimated using the small open-economy model (Fig-1). This was done by assigning the elasticity parameter (11). The analysis was undertaken for each year over the years 1986-87 to 2000-01. However, a research and development lag of five years was employed : research expenditures started in 1980-81, extension expenditures started in 1986-87, and benefits started arriving in 1986-87. The yearly total social benefits are presented in Table-5 along with total research and extension expenditures.

Using various parameters mentioned earlier, the IRR was estimated to be 23 percent for the maize research and extension (Table-5) i.e., on the average, each Taka invested in agricultural research and extension, returns 23 percent annually from the date of the investment. Another interpretation is that if the yearly research and extension expenditures had been borrowed at an interest rate of 23 percent, the social benefits from research and extension would equal the cost of borrowing the funds. The Benefit cost ratio was found 11.

Table-5. Rate of return to maize research and extension through Ex-post Analysis

Year	Supply Elasticity	Demand Elasticity*	Supply Shifter k	Maize Price (Tk/ton) (Po)	Maize Quantity (ton) (Qo)	Change in Consumer Surplus (CS)	Change in Producer Surplus (PS)	Change in Total Surplus (TS)	Research & Extension Costs (C)	Total Input Cost Change
1980-81	0.20	1000000000000		21784	1355				1833610	
1981-82	0.20	1000000000000		20599	1322				1655056	
1982-83	0.20	1000000000000		18707	1173				4168367	
1983-84	0.20	1000000000000		17802	3000				7201393	
1984-85	0.20	1000000000000		16807	3270				5512885	
1985-86	0.20	1000000000000		15113	3000				6742191	
1986-87	0.20	1000000000000	0.013	14108	2934	0	517424	517424	2590852	17837173
1987-88	0.20	1000000000000	0.038	13458	2855	0	1460010	1460010	2547440	17837173
1988-89	0.20	1000000000000	0.033	12476	3229	0	1329406	1329406	2880699	18558590
1989-90	0.20	1000000000000	0.050	11702	3350	0	1940505	1940505	2617259	18426422
1990-91	0.20	1000000000000	0.072	10767	3040	0	2364803	2364803	3051007	17121263
1991-92	0.20	1000000000000	0.094	10420	3000	0	2946229	2946229	3348808	19825200
1992-93	0.20	1000000000000	0.251	10324	7000	0	18169492	18169492	15658580	27865420
1993-94	0.20	1000000000000	0.285	10090	15000	0	43155029	43155029	17475409	35244800
1994-95	0.20	1000000000000	0.340	9574	29075	0	94698115	94698115	9721161	54739580
1995-96	0.20	1000000000000	0.395	9184	32000	0	116144606	116144606	12063142	55758375
1996-97	0.20	1000000000000	0.427	9613	40690	0	166893415	166893415	23120204	69784704
1997-98	0.20	1000000000000	0.504	9335	65279	0	306823822	306823822	45623248	82263566
1998-99	0.20	1000000000000	0.574	8716	84880	0	424558314	424558314	15878726	101846458
1999-00	0.20	1000000000000	0.635	8143	120691	0	624523652	624523652	22881145	124116766
2000-01	0.20	1000000000000	0.657	7500	149244	0	735848772	735848772	15937463	143060846

* A sufficiently large number to make the consumer surplus equal to zero.

Contd.....Table/5

Year	Net Benefit (NB)	Change in Price in Absence of New Varieties (Pn-Po)	Price in Absence of New Varieties (Pn)	Area ABC	Area AOC	Area BPPC (PnPoBA)
1980-81	-1833610					
1981-82	-1655056					
1982-83	-4168367					
1983-84	-7201393					
1984-85	-5512885					
1985-86	-6742191					
1986-87	-19910601	12,355,212,355	12,355,212,355	0	517424	0
1987-88	-18924602	18,532,818,533	18,532,818,533	0	1460010	0
1988-89	-20109883	37,065,637,066	37,065,637,066	0	1329406	0
1989-90	-19103175	61,776,061,776	61,776,061,776	0	1940505	0
1990-91	-17807467	92,664,092,664	92,664,092,664	0	2364803	0
1991-92	-20227780	92,664,092,664	92,664,092,664	0	2946229	0
1992-93	-25354508	123,552,123,552	123,552,123,552	0	18169492	0
1993-94	-9565180	154,440,154,440	154,440,154,440	0	43155029	0
1994-95	30237373	154,440,154,440	154,440,154,440	0	94698115	0
1995-96	48323089	209,039,148,783	209,039,148,783	0	116144606	0
1996-97	73988507	251,167,930,952	251,167,930,952	0	166893415	0
1997-98	178937007	268,643,788,320	268,643,788,320	0	306823822	0
1998-99	306833130	268,643,788,320	268,643,788,320	0	424558314	0
1999-00	477525740	268,643,788,320	268,643,788,320	0	624523652	0
2000-01	576850463	268,643,788,320	268,643,788,320	0	735848772	0

Results:

Net Present Value Benefits (NPV) = Tk 187,874,568
Internal Rate of Return (IRR) = 23%
Present Value Research Cost (PVRC) = Tk 60,220,109

Table-6. Price of maize and foreign exchange savings from investment in maize research and extension

Year	Harvest Price (Tk/ton) (current Taka)	Harvest Price Deflated (base: 2000/01=100)	Import Price (Tk/ton)	Import Price Deflated (Base:2000/01=100)	Supply Shifter k	Maize Production (ton)	Increase in Production from Research (ton)	Foreign Exchange Savings (Taka)	CPI Middle Income Group (base: 2000/01=100)
1980-81	5250	21784							24.10
1981-82	5500	20599							26.70
1982-83	5500	18707							29.40
1983-84	5750	17802							32.30
1984-85	6000	16807							35.70
1985-86	6000	15113							39.70
1986-87	6250	14108			0.013	2934	37		44.30
1987-88	6500	13458			0.038	2855	108		48.30
1988-89	6500	12476			0.033	3229	107		52.10
1989-90	6600	11702			0.050	3350	166		56.40
1990-91	6600	10767			0.072	3040	220		61.30
1991-92	6700	10420			0.094	3000	283		64.30
1992-93	6700	10324	60000	92450	0.251	7000	1760	162711864	64.90
1993-94	6750	10090	60000	89686	0.285	15000	4277	383600256	66.90
1994-95	6750	9574	65000	92199	0.340	29075	9891	911907770	70.50
1995-96	6750	9184	65000	88435	0.395	32000	12647	1118429543	73.50
1996-97	7200	9613	75000	100134	0.427	40690	17362	1738473071	74.90
1997-98	7300	9335	75000	95908	0.504	65279	32868	3152299536	78.20
1998-99	7400	8716	85000	100118	0.574	84880	48709	4876683340	84.90
1999-00	7500	8143	90000	97720	0.635	120691	76692	7494283820	92.10
2000-01	7500	7500	95000	95000	0.657	149244	98113	9320751112	100.00

Total Foreign Exchange Savings = Tk 29,159,140,314 = Tk 291.59 billion

Foreign Exchange Savings

Local demands of maize are met by imports every year in addition to local production. Recently, farmers have adopted composite varieties as well as hybrids of maize. As a result, area, production and yields of maize have increased dramatically. Therefore, import quantities are becoming less every year due to higher production of maize. Again, this results foreign exchange saving and the cumulative figure of this saving is found 291.59 billion Taka (Table-6).

Sensitivity Analysis

A sensitivity analysis was undertaken in the study. When the yearly supply shifter k was decreased by 25 percent, there was a decrease in the rate of return to 17 percent, BCR 9 (Table-7). When the supply shifter k was increased by 25 percent, the IRR increased to 27 percent and BCR 14. When the expenditures were decreased by 25 percent, the IRR was increased to 25 percent and BCR increased to 15. When the expenditures were increased by 25 percent, the IRR was decreased to 21 percent and BCR decreased to 9. A simultaneous increase of 25 percent in the supply shifter and a 25 percent decrease in expenditures gave rise to a 28 percent IRR with BCR 19. Again, with the 50 percent increase and 50 percent decrease in the supply elasticity, there were no change in IRR and BCR.

Table-7. Sensitivity analysis on the returns to maize research and extension

Parameters	Internal Rate of Return (IRR) (%)	Net Present Value (NPV)	Benefit Cost Ratio
1. Base parameters	23	187.87	11
2. Supply shifter k decreased by 25%	17	83.25	9
3. Supply shifter k increased by 25%	27	292.50	14
4. Expenditure decreased by 25%	25	202.93	15
5. Expenditure increased by 25%	21	172.82	9
6. Expenditure decreased by 25% and supply shifter k increased by 25%	28	307.55	19
7. Supply elasticity increased by 50%	23	187.87	11
8. Supply elasticity decreased by 50%	23	187.87	11

IV. CONCLUSIONS

- The growth rates of area, production and yield of maize increased dramatically after the release of composite varieties and hybrids of maize.
- During 2000-01, about 65.70% more maize production was made available because of the farmers' adoption of composite varieties and hybrids of maize.
- The yield of composite varieties of maize ranged from 40 to 65% and hybrids ranged from 73 to 79% higher over the local varieties.
- The internal rate of return (IRR) to investment was estimated at 23%.

- Under various assumptions about the research and extension expenditures, the IRR ranged from 17 to 28% and benefit cost ratio from 9 to 19.
- The accumulated foreign exchange saving since 1992-93 was Tk 291.59 billion.
- The study indicates that the funding of maize research and extension is a good investment.
- The result of the *ex-post* analysis indicates that the society will receive a very high return to its future investment in maize research at BARI.
- To achieve the target of self-sufficiency in food, sustainability in agricultural development and to keep the flow of maize research in right track, more investment on maize is needed.
- Therefore, both government and donor agencies should come forward to invest in maize research and strengthen extension activities in the country.
- Further, in terms of resource allocation, the maize-based cropping patterns should get high priority.

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Appendix-1: Research and Extension Expenditures for Maize in Bangladesh

Year	Expenditures Incurred by Different Institutes (current Taka)								Total Expenditure Deflated (base: 2000/01=100)	CPI Middle Income Group (base: 2000/01=100)	Input Cost Change (Tk) [5507*Maize area]
	BARI Main (1.0%)	BARI Maize Project (0.50%)	BARC Expenditures	GKF Expenditures	UNDP Expenditures	ASSP Expenditures	DAE Expenditures	Total Expenditure			
1980-81	300000		141900					441900	1833610	24.10	
1981-82	300000		141900					441900	1655056	26.70	
1982-83	340000		885500					1225500	4168367	29.40	
1983-84	348000	1,160,000	818050					2326050	7201393	32.30	
1984-85	174000	1,160,000	634100					1968100	5512885	35.70	
1985-86	560000	1,160,000	956650					2676650	6742191	39.70	
1986-87	550000		539250				58498	1147748	2590852	44.30	17837173
1987-88	600000		562700				67713	1230413	2547440	48.30	17837173
1988-89	610000		819500				71344	1500844	2880699	52.10	18558590
1989-90	640000		746050				90084	1476134	2617259	56.40	18426422
1990-91	675000		1107250				88017	1870267	3051007	61.30	17121263
1991-92	700000		1346100				107184	2153284	3348808	64.30	19825200
1992-93	800000		798650	8381100			182668	10162418	15658580	64.90	27865420
1993-94	849930		225500	10368280			247339	11691049	17475409	66.90	35244800
1994-95	905000		171400	5407080			369939	6853419	9721161	70.50	54739580
1995-96	946000		261250	7253400			405760	8866410	12063142	73.50	55758375
1996-97	970000		675850	15021760		100,000	549423	17317033	23120204	74.90	69784704
1997-98	1051500		675850	33202360		100,000	647670	35677380	45623248	78.20	82263566
1998-99	1051500		675850	10851840	100,000		801848	13481038	15878726	84.90	101846458
1999-00	1051500		675850	18369000			977185	21073535	22881145	92.10	124116766
2000-01	1051500		1181750	12516040			1188173	15937463	15937463	100.00	143060846

Note: BARI= Bangladesh Agril. Res. Inst; BARC=Bangladesh Agril. Res. Council; GKF = Grameen Krishi Foundation; UNDP= United Nations Development Program; ASSP= Agriculture Support Service Program; DAE= Department of Agricultural Extension; CPI = Consumer Price Index.